4.3 Hydrology and Geothermal Resources

SIGNIFICANCE CRITERIA

The proposed action would be considered to have a significant impact on the environment if it would:

- Substantially deplete or degrade groundwater resources
- Change the amount of surface water in any water body
- Contaminate a public water supply
- Substantially degrade water quality
- Interfere substantially with groundwater recharge
- Cause substantial flooding, or expose people or property to water-related hazards such as flooding
- Substantially deplete or degrade the geothermal resource

METHODOLOGY

This analysis was performed by evaluating available data, information and reports. These materials are listed in Section 7.0, References. No additional data collection or field investigations were performed.

IMPACT OVERVIEW

Potential effects of the proposed project on hydrologic resources are limited to the effect of discharge of geothermal effluent on surface water quality, primarily the Pit River. These impacts have been thoroughly addressed in the NPDES Waste Discharge Requirements, Order No. R5-2002-0079 (the Order); compliance with that Order encompasses required mitigation measures for potential water resources impacts. If the requirements, limitations, and monitoring required by the Order are implemented no significant impact on water quality related to project operations would result (Finding 19 of the Order) and therefore no additional mitigation measures are indicated.

EFFECTS OF PROPOSED ACTION

Water Use

No increase in potable water use is projected for the proposed project. Potable make-up water would be pumped from the on-site potable water well to replace hot water drawn for domestic use from the circulating heating water. The amount of domestic potable make-up water would be approximately 3,660 gallons per day (gpd). Hot water consumption would not necessarily change as a result of the project because the existing water consumption will move to the new buildings. The impact to potable water would be less than significant.

Groundwater Water Quality

Local groundwater quality could be adversely affected if geothermal fluids were mixed with groundwater. The geothermal well presents a potential conduit for cross contamination between the aquifers. Surface infiltration of spills of geothermal fluid from the well and heat exchange facilities of the pipeline present a possible additional pathway for the mixing of geothermal fluids and shallow groundwater.

Groundwater quality is typically protected during drilling of geothermal wells by sealing shallow groundwater with appropriate casing and cement. The project well is cased and sealed with telescoping casing to 1,600 feet below ground surface (bgs). Caliper logs indicate that the casing is intact; therefore, it is highly unlikely that shallow aquifers would be affected. Proper well maintenance and future well abandonment required by DOGGR regulations will protect the integrity of the well and surrounding groundwater in the future.

Because the project does not include additional drilling, surface spills of geothermal fluids would be limited to geothermal fluid from the wellhead, heat exchanger, or pipeline. Given the low flow rates (a maximum or 60 gpm), the volume of spill is unlikely to be sufficient to cause an adverse impact to groundwater quality (see also the discussion of potential effects of spills in Section 4.12, Health and Safety).

Pipeline Breakage. Buried pipelines can break because of natural earth movement, corrosion, or accidental damage. Natural earth movement capable of breaking the pipeline includes seismic movement, shrinking and swelling of clays, and landslides. Although significant movement related to seismic activity or landslides is unlikely, (see Section 3.2, Geological Resources) soils in the area have a moderate to high shrink swell potential and are corrosive. Implementation of Mitigation Measure 4.3-1 will reduce the risk pipeline breakage due to the potential soil conditions (e.g. high shrink-swell potential and corrosivity) to a less than significant level. Additionally, the pipeline would be made of polyvinyl chloride (PVC) and would be less susceptible to corrosion than metal piping.

The proposed buried discharge pipeline presents a potential to affect shallow groundwater if the pipeline breaks and geothermal effluent is discharged directly to the ground. The gravel bed on which the pipe would be laid would conduct any water leaks downward. A leak of sufficient volume and duration could seep into groundwater. Groundwater depth below the pipeline varies from 20 ft to approximately 3 ft bgs as it approaches the Pit River. Mercury levels in the treated effluent would meet drinking water standards, but arsenic and boron levels would not. The implementation of Mitigation Measure 4.3-1 would reduce the likelihood of a pipeline break, and potential for contamination of groundwater, to a less than significant level. The implementation of Mitigation Measures 4.3-2 would reduce the likelihood of a leak of substantial volume remaining undetected for more than a month to less than significant level.

The risk of accidental damage will be reduced to a less than significant level by the laying of the pipeline 3 feet below the ground surface. This depth would ensure the pipeline's safety from accidents related to normal small town and farming activities such as cultivation and vehicular traffic. Major accidents such as drilling or digging with large construction equipment right on top of the pipeline would be required to cause a breakage.

Based on conversation with the RWQCB (Rohrbach 2002) it was determined that given the specifications of the discharge pipeline, the pipeline leak monitoring method initially outlined in the WDR (Appendix D) required more detail. Monthly inspection of the pipeline route would reveal only those leaks due to surface disturbance activities that may have damaged the pipeline (Rohrbach 2002). The 3-foot deep pipeline would be laid on a gravel bed, directing leaking fluids downward. Surface pooling of leakage would be unlikely and measurements of flow or pressure-testing would be more effective at detecting leaks due to underground causes (Rohrbach 2002). Mitigation Measure 4.3-2 was developed in consultation with the project engineer (Brian Brown, Brian Brown Engineering) and combines both inspection of the pipeline route for surface disturbance and pressure testing of the pipeline. This measure would ensure that major leaks caused suddenly by construction or other ground-disturbing activities are detected within one month of occurrence, and minor leaks caused gradually by earth-shifting or pipeline degradation are detected within one year of occurrence. Implementation of Mitigation Measure 4.3-2 would reduce the risk of groundwater contamination to a less than significant level.

Surface Water Quality

Expression of Contaminant Levels. The magnitude of adverse effects that contaminants have on the health of humans and other organisms varies significantly from contaminant to contaminant. Drinking water standards for one contaminant may be orders of magnitude higher or lower than the standard for another contaminant. To avoid using excessive zeroes and decimal places, standards for individual contaminants are expressed in units most appropriate for the respective magnitude of the number. In this document, the units used are primarily nanograms per liter (ng/L) and micrograms per liter (μg/L). Arsenic and boron, for example, are expressed in micrograms per liter (μg/L), whereas mercury is expressed in nanograms per liter (ng/L). One thousand nanograms equals one microgram. Five micrograms is one thousand times more than 5 nanograms. The project proponent submitted a Report of Waste Discharge dated July 11, 2001 and applied for a NPDES permit to discharge waste. The NPDES Permit No. CA 0084859 was issued on May 13, 2002 by the CVRWQCB with the following specific restrictions, limitations and monitoring requirements.

1. Discharge will occur through a 4-inch diameter polyvinyl chloride (PVC) line and a diffusion manifold into the Pit River approximately 425 feet upstream from Modoc County Road 54 Bridge.
2. Discharge effluent temperature shall be ≤80 °F.
3. The discharge of effluent is prohibited when dilution by river water is less than 22.5:1.
4. The by-pass or overflow of effluent from the collection, transport, treatment, or disposal facilities to surface waters other than those designated for disposal purposes is prohibited.
5. The discharge of effluent to the Pit River with concentrations of arsenic >10 μg/L or mercury >50 ng/L is prohibited.
6. The maximum rate of effluent discharge shall not exceed 0.087 million gallons per day (or 60 gpm averaged over one day).
7. The effluent discharge pH shall be between 6.0 and 9.0.
8. Survival of aquatic organisms in 96-hour bioassays of undiluted effluent shall be no less than: Minimum for any one bioassay = 70%; Median for any 3 or more consecutive bioassays = 90%.
9. Receiving water (Pit River) must meet various limits as outlined in Table 4.3-1.

In order to achieve these objectives and limitations, the project proponent is required to install and operate a mercury treatment system, and comply with the orders Monitoring and Reporting program, which includes conducting fish tissue analysis, chronic toxicity testing, and periodic water quality monitoring.

Mercury. The Waste Discharge Requirement (WDR, Appendix D) sets 50 ng/L of mercury as the limit for both the receiving water and the effluent. Mercury levels in water from the geothermal well have been shown to be as high as 231 ng/L (Basic Laboratory 2002); therefore, the WDR requires a mercury abatement system for the effluent as well as monitoring to determine the efficacy of that system. Testing of the granular activated carbon (GAC) filtration (bench scale testing conducted by Basic Laboratory Inc, April 18, 2002, see Appendix I) indicated that mercury removal efficiencies ranged from 92 to 99%, depending on the flow rate of the water through the filter. At 92 to 99% removal efficiency, the GAC filter system is expected to yield effluent mercury levels within the 2 to 19 ng/L range. This suggests that available technology is capable of achieving lower effluent mercury levels than those required by the WDR.

Table 4.3-1: NPDES Permit Receiving Water Limitations

Constituent	Limitation in Receiving Water
Arsenic	<10 μg/L
Boron	<600 μg/L
Mercury	<50ng/L
Dissolved Oxygen	<7 mg/L
Oil, grease, wax or any material	Visible film or nuisance or adverse effect on beneficial use
Chlorine	<detection
Discoloration	Aesthetic desirability
Fungi, slime or other objectionable growth	<Any
Turbidity	<1 NTU when background is 0-5 NTU
	<20% when background is 5-50 NTUs
	<10 NTUs when background is 50-100 NTUs
	<10% when background is>100 NTUs
pH	6.5 < pH < 8.5; change of >0.5 prohibited
Temperature	<5°F
Radionuclides	<MCLs CCR Title 22
Taste or Odor	Undesirable or adverse effect on beneficial use
Toxic pollutants	Prohibited
Applicable water quality standards	Violations prohibited

SOURCE: CVRWQCB WDR No. R5-2002-0079 2002

Due to its bioaccumulative properties and the potential effects on wildlife, mercury was not given a dilution credit by the water board. Withholding a dilution credit for mercury serves to limit the total amount of mercury entering the river, but does not mean that dilution does not occur. For the purposes of modeling mercury concentrations in the Pit River, river flow rates and effluent flow rates are used along with background river mercury concentrations and predicted effluent mercury concentrations.

The WDR recognizes that under worst-case conditions, dilution of the effluent occurs at a factor of 22.5 as it mixes with River water. Worst-case conditions would occur with a Pit River flow rate of 3 cubic feet per second, an effluent flow rate of 60 gallons per minute, and an effluent mercury concentration of 50 nanograms per liter.

The Pit River typically only reaches flow rates as low as 3 cfs in dry, summer conditions. The effluent flow rate of 60 gallons per minute is the highest level permitted; however, preliminary flow testing has shown a peak flow rate of 37 gallons per minute from the well. Peak flow of 37 gpm is expected only during winter months when maximal use of the geothermal heat is required.

Effluent mercury levels of 50 ng/L is the maximum permitted under the WDR; however, preliminary testing of the carbon treatment system suggests that treated effluent mercury levels will be in the range of 2 to 19 ng/L. The following analysis assumes these highly unlikely conditions (flow rate of 60 gpm and mercury concentration of 50 ng/L) to provide a worst-case scenario. Actual effects to water quality would be less.

A dilution factor of 22.5 applied to an effluent containing 50 ng/L of mercury would result in an increase in river mercury levels of 2.2 ng/L. Baseline Pit River mercury levels at the point of discharge averaged 1.72 ng/L (Frontier Geosciences 2002, Appendix I). For further details on baseline mercury levels in the Pit River, see the discussion below. An addition of a maximum of 2.2 ng/L to an average baseline concentration of 1.72 ng/L would result in a maximum post-effluent River concentration of 3.9 ng/L, well below the EPA limit for human drinking water of 50 ng/L. Compliance with human drinking water quality standards does not necessarily translate to compliance with standards or thresholds determined to be protective of wildlife. Effects on wildlife are discussed in Section 4.4, Biological Resources.

The Pit River mercury value of 1.72 ng/L resulting from the analysis by Frontier Geosciences in 2002 (Appendix I) differs considerably from the value for mercury concentrations in the Pit River quoted in the WDR (9.7 ng/L). The 9.7 ng/L value for mercury concentration is an average of results from samples collected by the RWQCB on July 31, 2001 for the WDR, and by Dale Merrick on June 25, 2001 for the California Toxics Rule (Rohrbach 2002). The summer season of 2001 was unusually dry, and a background mercury level in the range of 9.7 ng/L seems highly unusual (Rohrbach 2002). This value is a poor indicator of normal summer mercury levels in the Pit River because of the drought (Rohrbach 2002). In July of 2001, the flow rate of the river was less than 3 ft/s from July 7th through August 3rd.The Pit River upstream of Canby was completely dry until the point of discharge from the Alturas wastewater treatment facility in Alturas (Rohrbach 2002). It is likely that the only sources of water in the Pit River at Canby were the treated wastewater effluent from Alturas, the estimated 400 gallons per minute coming from Kelley Hot Springs, and any agricultural runoff occurring between Alturas and Canby. Water from Kelley Hot Springs is estimated to have mercury levels of 15 ng/L and enters the Pit River at approximately 2 miles upstream from Canby. Under the extremely dry conditions of 2001, it is conceivable that the bulk of water in the Pit River at Canby originated from Kelley Hot Springs, resulting in mercury levels in the range of 10 ng/L.5

On the day of sampling, the river exhibited its 25th consecutive day with a flow rate of less than 3 ft/s. According to USGS data, the average flow for July of 2001 was 8.60 ft/s, while normally, the average flow for July (taken from 1904-2001) is 65.9 ft/s (USGS archived data 2003). This drought would have attributed to the unusually high mercury concentration.

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The unusually dry conditions of 2001 make 9.7 ng/L a poor indicator of normal summer mercury levels in the Pit River. Such conditions may occur from time to time; however, when flow rates are less than 3 ft/s permits do not allow discharge. September 2002 was also a dry year and had a flow rate average of 12.57 ft/s. Normally, the average flow rate in September (taken from 1904 to 2001) is 82.0 ft/s (USGS archived data 2003). Since flow rates were higher than 3 ft/s for 25 of 30 days in September, this data was more appropriate to use, although still representing a conservative case, given that the flow rate was well below the monthly average. Mercury levels are expected to be even lower than the 1.72 ng/L range under more normal conditions (Rohrbach 2002). To achieve a more representative estimate of impacts to the river, the 2002 data was used for the water quality impact analysis.

Arsenic. Geothermal effluent has been shown to contain arsenic in the range of 98 to 110 µg/L. This level exceeds the US EPA Maximum Contaminant Level (MCL) for arsenic of 50 µg/L and the Basin Plan Water Quality Objective of 10 µg/L. Unlike mercury, arsenic does not bioaccumulate; therefore, it is not of concern for wildlife such as the bald eagle which preys on fish in the Pit River. The WDR (Appendix D) sets a dilution credit of 22.5, which is the expected dilution ratio in the river during low flow season conditions at maximum geothermal flow of 60 gpm. At an effluent concentration of 110 µg/L and a dilution factor of 22.5, the discharged arsenic would be diluted to a concentration of 5 µg/L in the Pit River. The effluent arsenic concentration limit in the WDR is set at 150 µg/L.

The CVRWQCB indicated (Finding 19) that compliance with the requirements of the order would result in an insignificant impact on water quality; therefore, no additional mitigation measures are required.

Boron. Geothermal effluent has been shown to contain boron in the range of 3240 to 4090 µg/L, exceeding the applicable receiving water quality standard. Boron is not expected to increase in the discharge over time. The receiving water objective established in the WDR is 600 µg/L. Based on the mixing zone study (Appendix J) and a required minimum dilution of 22.5:1, the discharge would meet the receiving water limit at the diluted levels of 144 to 182 µg /L. An effluent limitation has not been established for boron (Appendix D).

Flooding

The proposed project does not alter the drainage and therefore will not affect flooding in the area. The buried pipeline would not be affected by flooding.

Geothermal Resource

The proposed project would include extraction of an annual average of 15 gallons per minute (gpm) of geothermal fluid from the geothermal aquifer. Pressure in the aquifer causes geothermal fluids to naturally surface at Kelley Hot Springs at an approximate flow rate of 400 gpm, approximately 2 miles from the I'SOT community. The relatively low flow extraction rate would have a less than significant impact on the geothermal resource.

Due to the moderate average withdrawal rate of approximately 15 gpm, distance from other uses (Kelley Hot Springs is approximately 2 miles east), and lack of cooler water injection, no adverse impacts to the geothermal resource are anticipated. At Kelley Hot Springs there is a natural surfacing of geothermal fluids at a rate of approximately 400 gpm, indicating a surplus of geothermal fluid in the aquifer. The modest extraction rate of an average of 15 gpm would not have a significant impact on the geothermal resource, and injection of withdrawn fluids is not required to protect the geothermal resource.

MITIGATION MEASURES

Mitigation Measure 4.3-1. I'SOT will design and construct the pipeline according to standard engineering practices and codes such as the American Water Works Association (AWWA) or American Society of Mechanical Engineers (ASME) Power Piping Code B31.1.

Mitigation Measure 4.3-2. I'SOT shall inspect the pipeline route on a monthly basis for possible pipeline damage generated from surface activities such as construction. Potential damage will be investigated and repaired, if necessary. I'SOT shall, upon pipeline installation and on an annual basis thereafter, perform a pressure test of the discharge pipeline. The pressure test shall involve blocking the pipeline at the discharge point such that no discharge escapes, filling the pipeline with water, and observing the water level at the head of the pipeline over time. A fall in water level indicates a leak in the pipeline and shall be followed by shutdown of the geothermal flow. Use of the discharge pipeline shall not recommence until the leak is identified, repaired, and a further pressure test indicates the pipeline is sealed. The leakage limit will be set as the manufacturer's estimate for leakage under the project's operating conditions. I'SOT shall provide the results of this testing to NREL during the first 3 years of operation.

Mitigation Measure 4.3-3. The WDR sets 50 ng/L as the limit for mercury concentration in the effluent to be protective of water quality and wildlife. The GAC filter system removes 92-99% of incoming mercury yielding effluent mercury levels within a 2-19 ng/L range. Higher concentrations in the effluent may suggest declining filter efficacy. I'SOT will replace the GAC filters according to manufacturer's specifications. The mercury concentration in the effluent will be monitored monthly for the first six months and quarterly thereafter. If mercury concentrations in the effluent are found to be 45 ng/L, I'SOT will replace the GAC filters.

EFFECTS OF ALTERNATIVE B (NO ACTION)

If the project were not constructed due to lack of DOE funding, there would be no adverse effects to hydrologic or geothermal resources from Alternative B, the "No Action" alternative; however, the project could proceed without DOE funding contingent upon alternative funding, with effects from Alternative A potentially worse without DOE participation because no mitigation would be required (except NPDES required items). The following measures would not be implemented without DOE involvement: 4.3-1 and 4.3-2. Without funding by DOE, I'SOT would not be reimbursed for costs resulting from permitting efforts, engineering consultation, and system installation costs. No data gathering system would be installed for DOE research and development (R&D) purposes.